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New data from the historical bee collection (Hymenoptera, Anthophila) of the Science Museum of the University of Coimbra and additional faunistic updates for Portugal

Hugo Gaspar[1], Simone Flaminio[2], Albano Soares[3], Cristina Rufino[1,4], João Loureiro[1], Sílvia Castro[1], Thomas J. Wood[5]

1 *Centre for Functional Ecology, Department of Life Sciences, University of Coimbra, Coimbra, Portugal* **2** *Laboratory of Zoology, Research Institute for Biosciences, University of Mons, Mons, Belgium* **3** *Tagis - Centro de Conservação das Borboletas de Portugal, Avis, Portugal* **4** *Science Museum of the University of Coimbra, Coimbra, Portugal* **5** *Naturalis Biodiversity Center, Leiden, Netherlands*

Corresponding author: Hugo Gaspar (hgaspar@uc.pt)

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Abstract

Entomological collections hold significant scientific potential, especially understudied taxa of historical collections from important biogeographical regions, such as bees in Portugal. The Science Museum of the University of Coimbra (MCUC) holds the largest historical collection of Portuguese bees, primarily because M.A. Diniz, one of the few Portuguese bee experts, was based in this institution during the 20th century, and several historical collections are stored there from that period and before. Nevertheless, most of the records were unpublished and unrevised. In this work, we revised and databased (via GBIF) 13,374 Portuguese bee records (11,053 unpublished), covering 464 species, of which 11 are new to Portuguese fauna. All 9 type specimens from Portuguese species (1 holotype, 2 syntypes, 5 paratypes and 1 dismissed type) were reported and photographed. We also provide an update of the Anthophila checklist for continental Portugal, with three additional unreported species from other institutions (for a total of 14 new species) and removal or confirmation of exclusion of 19 previously reported species, producing a revised total for the Portuguese continental bee fauna of 736 species.

Keywords

Biodiversity, digitization, natural history collections, pollinators, wild bees

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Introduction

Entomological collections are crucial to significantly improving our knowledge of the entomofauna (Short et al. 2018). Our understanding of national bee fauna is particularly dependent on these collections due to the challenge of morphological identification without collected specimens (Reverté et al. 2023). Through verified specimens, entomological collections allow the confident exploration of the distribution, phenology, morphological variability and biological material sources, directly feeding most taxonomic and ecologic studies (i.e., Scheper et al. 2014; Oliveira et al. 2016; Rasmussen et al. 2016; Dorchin 2023). Portugal is the 9th most bee species-rich European country (Reverté et al. 2023), benefiting from its geographic position, with Mediterranean influence in most of the continental territory and an Atlantic influence in the north-western part, as well as insular territories in the Macaronesia territories (Michener 2007; Reverté et al. 2023).

Due to the vital role of bees in the sustainability of terrestrial ecosystems, playing an important role in multiple ecosystem services (most noticeably, pollination) (Klein et al. 2007; Willmer et al. 2017), there has been a significant shift in the research investment across Europe (Reverté et al. 2023). This has uncovered deficiencies in data sources and taxonomic work (amongst others) all over the continent (Ghisbain et al. 2023). The knowledge of the bees of Portugal is moderate as the first comprehensive checklist was only published in 2018 by Baldock and collaborators, gathering data from published literature and additional collections, mostly held internationally by private collectors (Baldock et al. 2018). This work was a milestone that triggered the study of new data sources, historical and contemporary. The European movement involves Portugal in several European initiatives to improve bee taxonomic capacity, monitoring and reference collections, such as projects "SPRING - Strengthening Pollinator Recovery through INdicators and monitorinG" (2021–23) and "TETTRIs - Transforming European Taxonomy through Training, Research and Innovations" through the third-party project "ARCADE - Aligning Reference Collections with tAxonomic Development Efforts for pollinator conservation in Portugal", (2024–25).

The Portuguese bee collection at the Science Museum of the University of Coimbra (MCUC, Portugal) was actively built and studied intermittently for more than 100 years from the late 19th century to the early 21st century, most noticeably by its main curator and collector, the hymenopterist M.A. Diniz, based in Coimbra (Diniz 1959, 1960, 1961a, 1961b, 1989). In this collection, the most noticeable sources of Portuguese material include a mixed collection, the so called "Old Collection", from naturalist expeditions made by the staff of the University of Coimbra (based in Coimbra) and São Fiel College (based in Castelo Branco), up to the beginning of the 20th century; the private collection of N.F. d'Andrade (based in Estoril), and collections from M.A. Diniz and associates - these last two mostly from mid-20th century. Besides the bee specimens collected in Portugal, there are specimens from many countries (primarily European reference material) that were exchanged by M.A. Diniz with the museums of Madrid (Spain) and Paris (France) during collaborations in the 1960s and the 1980s,

respectively (M.A. Diniz, pers. comm.), that significantly improved reference material for the identification of Portuguese bee species.

Mostly in the second half of the 20th century, several bee taxonomists visited the MCUC entomological collection or exchanged a portion of the material. This resulted in several literature references to the collection or the exchanged material (literature list presented in the results). Baldock et al. 2018 did not revise this collection. They highlighted the need to do so, especially considering that it is the most extensive collection of Portuguese historical material after the loss of the collection from the National Museum of Natural History and Science (Lisbon, Portugal) in a fire in the late 1970s (Mendes et al. 2021). Despite its immense scientific potential, by the time the current work was started in 2022, the MCUC bee collection was not centralized, and no additional documentation (catalogue, material exchanges, visiting schedules) was available beyond the published literature.

With these considerations on the MCUC Bees of Portugal collection in mind, the main objective of the current work was to revise this historical collection and update the current knowledge of Portuguese bee fauna. In particular, we aimed: 1) to provide a taxonomic revision of the bee collection, contributing with novel georeferencing of the specimens and specimen-record links to published literature through the creation of a GBIF dataset; 2) to provide an insight on bee species representation, geographic coverage, phenology and historical periods at a country-level context within this collection; and 3) to provide an updated list of bee species, with new records and photographs of new species additions to the Portuguese bee fauna (including also a few external sources), and existing type material of Portuguese species. This work brings new data on the Portuguese bee fauna and an insight into a neglected but vital collection, promoting the overall potential of future works on Portuguese and Iberian bees.

Methods

All available bee specimens collected in Portugal and held in the MCUC collection were studied for this work. These specimens are referred to as the MCUC Bees of Portugal collection. Only material confirmed to have been collected in Portugal is reported in the present work, comprising 13,374 specimens, of which all but 61 were determined to the species level. However, 3,136 additional specimens were worked separately (i.e., were not included in the dataset) because of unknown geographic origin or because they do not belong to Portuguese Anthophila or Anthophila overall. Among the specimens excluded from the dataset, we nonetheless report the type material housed in the MCUC, belonging to Portuguese species.

Several steps were necessary to revise the MCUC Bees of Portugal collection, including specimen indexing, organization and taxonomic revision. For this, first, the original arrangement of the specimens in the original boxes was documented, and an individual code was assigned to each specimen. Additionally, all the information from the existing labels was databased (May 2022 to August 2023). Afterwards, we started indexation, and

the specimens received a new catalogue label and were moved to new boxes (August 2023 to October 2023). Then, the taxonomic revision process started and consisted of observing each specimen under the stereomicroscope (Wild Heerbrugg M5, with 10× oculars and 6 to 50× middle selector), comparing each specimen with reference material and using the most appropriate dichotomous keys to species level (October 2023 to May 2024). The taxonomic nomenclature follows Ghisbain et al. 2023. A total of 86 specimens were revised by bee experts, namely Thomas James Wood (*Andrena* Fabricius, 1775 and *Melitta* Kirby, 1802), Simone Flaminio (*Lasioglossum* Curtis, 1833 and *Halictus* Latreille, 1804), Achik Dorchin (*Eucera* Scopoli, 1770), Jakub Straka (*Nomada* Scopoli, 1770), Petr Bogush (*Coelioxys* Latreille, 1809), Pierre Rasmont and Guillaume Ghisbain (*Bombus* Latreille, 1802), and Romain Le Divelec (*Hylaeus* Fabricius, 1793). All the tasks done directly on the MCUC collection material required individual protection (facial mask 3M 4279+ and protective clothing) to reduce exposition to previous chemical treatments.

All the records with information about the collection site were georeferenced and added to a GBIF dataset – "Bees of Portugal Collection, Science Museum of the University of Coimbra" (Gaspar et al. 2025). Georeferencing each specimen was done on Google Earth using the toponyms provided on the specimen label. Toponyms not found in current maps were also searched in Portuguese toponyms databases (http://mapcarta.com and http://nominatim.openstreetmap.org). It also included personal insights on most frequent collection sites from M.A. Diniz (M.A. Diniz, pers. comm.). Variable levels of precision were obtained, ranging mostly from 10 m to 2.5 km. Additionally, in the GBIF database, we also linked some specimens to published literature based on the compilation of records made by Baldock et al. 2018. We linked the data by accepting the same identifier, locality and date (label on the specimen), in compatible time frames, depending on the paper details.

Relevant specimens were photographed, namely, male and female (when available) representative specimens from new species to Portugal (all species except two were photographed) and all the existing type material from Portuguese species. Photographs of each specimen were associated with its labels. The images were acquired with a Leica DMC4500 camera attached to a Leica Z6 APO microscope on a motorized focus stand to produce raw photo stacks processed to single montage images with Leica LAS X (v5.2.2.28326).

Additionally, 10 specimens from six collections harbouring bee specimens collected in Portugal were also considered for producing the updated list of bee species, namely: the FLOWer lab collection, São Bento College, University of Coimbra, Coimbra, Portugal (FLOW); the National Museum of Natural History and Science collection, Lisbon, Portugal (MUHNAC); the University of Mons collection, Department of Zoology, University of Mons, Mons, Belgium (UMONS); the Naturalis Biodiversity Center collection, Leiden, the Netherlands (RMNH); the A. Livory private collection, France; and K. Janssen private collection, Belgium.

The current continental Portugal bee fauna checklist was reviewed using literature revision and supporting information to our knowledge. Besides the new additions, we provided a list of removed species (with respective explanations) and compiled an updated fauna checklist.

Results

MCUC bees of Portugal

The MCUC Bees of Portugal collection includes 13,374 specimens (Suppl. material 1: table S1). This collection is represented by all six families of the current Portuguese bee fauna (Hymenoptera: Anthophila), by 45 out of the 55 genera (82% genus representation) and by 464 out of the 736 species (63% species representation) (Suppl. material 1: table S1). The genera not present in the dataset are *Halopanurgus* Wood, Patiny & Bossert, 2022, *Ammobatoides* Radoszkowski, 1867, *Biastes* Panzer, 1806, *Pasites* Jurine, 1807, *Afranthidium* Michener, 1948, *Aglaoapis* Cameron, 1901, *Dioxys* Lepeletier & Serville, 1825, *Ensliniana* Cameron, 1901, *Lithurgus* Latreille, 1825, and *Protosmia* Ducke, 1900. The species coverage and the number of specimens of each genus are presented in detail in Suppl. material 1: table S1. For every genus with more than one species, the collection species coverage is 66%, on average. The most noticeable gaps are found in relatively large genera, including *Tetralonia* Spinola, 1839 (10% of species represented) and *Hoplitis* Klug, 1807 (47% of species represented). On average, the collection harbours 29 specimens per species, with the most represented species being: *Andrena* (*Melandrena*) *flavipes* Panzer, 1799 (691 specimens); *Halictus* (*Hexataenites*) *scabiosae* (Rossi, 1790) (658 specimens); *Lasioglossum* (*Sphecodogastra*) *malachurum* (Kirby, 1802) (575 specimens); *Anthophora* (*Anthophora*) *plumipes* (Pallas, 1772) (557 specimens); and *Panurgus* (*Panurgus*) *perezi* Saunders, 1881 (399 specimens).

The timeframe of field collections extends for more than 100 years, with the first confirmed record being from 1876 and the last from 1990 (Fig. 1A). The most sampled time intervals are 1961–1970 (7,411 records), 1951–1960 (2,286) and 1876–1910 [2,015; this large time interval is due to the fact that most of the specimens prior to 1910 had no labelled year, and most of them are associated with the "Old Collection", which is confirmed to be dated up to 1910, M.A. Diniz pers. comm.]. By contrast, the least sampled decades are 1971–1980 (48), 1931–1940 (5) and 1911–1920 (1) (Fig. 1A). Regarding the coverage of sampling across the year, every month is represented, although most captures were made between March and August (Fig. 1B).

All 18 administrative districts and two insular archipelagos are represented in the collection (Fig. 2), topped by Coimbra (5,104 records), Porto (1,681), Lisboa (1,503), Faro (1,354) and Viseu (923) (Fig. 1C). By contrast, there are several districts with fewer than 100 records: Santarém (76), Guarda (74), Bragança (37), Açores (21), Madeira (8) and Vila Real (1).

There are 50 confirmed collectors, led by M.A. Diniz (6,845 records), N.F. d'Andrade (2,459), M.M. Correia (865), F.F. d'Almeida (296) and R.N. Ferreira (208) (Fig. 1D). M.A. Diniz collected from 1954 to 1989, as MCUC curator and entomologist based in Coimbra and also extensively collecting during vacations, mostly in Faro (M.A. Diniz pers. comm.). N.F. d'Andrade collected from 1941 to 1957, as an amateur hymenopterologist based in Estoril, Lisbon and Resende, Viseu (M. Pires pers. comm.). M.M. Correia collected from 1981 to 1983, as an entomologist based in

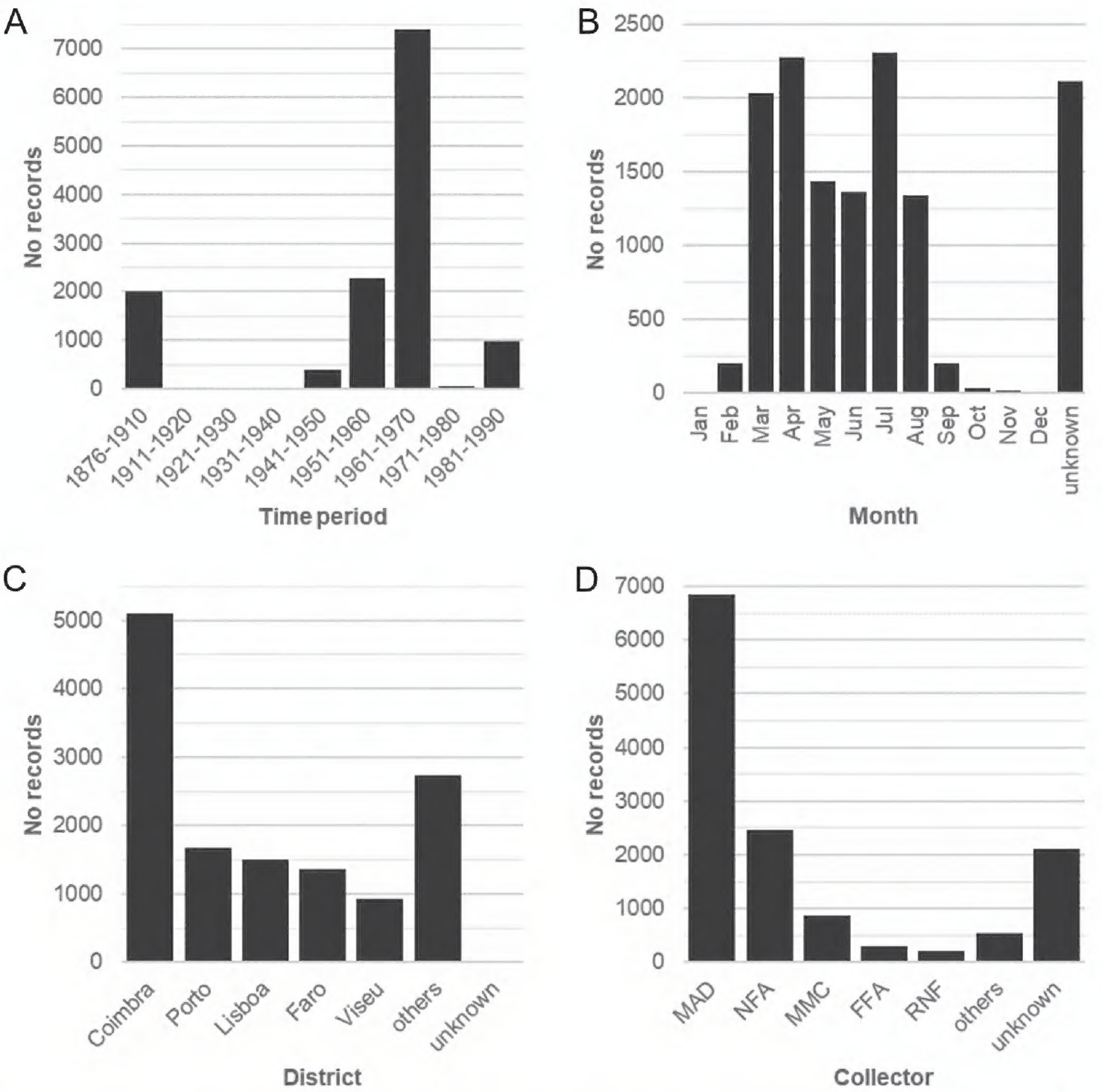

Figure 1. Bar charts representing the MCUC Bees of Portugal collection distribution of records by **A** decade (the first period includes 34 years, from the oldest confirmed date to the most recent possible date of undated records from the "Old Collection", as we could only ascertain that the records were older than 1910 and not to specific dates) **B** month **C** district and **D** collector: MAD – Manuel Assunção Diniz, NFA – Nuno Freire d'Andrade, MMC – Maria Maciel Correia, FFA – Fernando Ferrand d'Almeida, RNF – Raúl Nascimento Ferreira.

Vieiros, Porto. F.F. d'Almeida collected from 1958 to 1970, as an entomologist, based in Coimbra and Quinta do Bom Despacho, Lisbon. R.N. Ferreira collected from 1963 to 1987, based in Avelar, Leiria and Coimbra as university student and entomologist (R.N. Ferreira pers. comm.).

In the MCUC Bees of Portugal GBIF dataset, a total of 2,321 records were linked to previous literature, according to the checklist of Baldock et al. 2018. This literature includes taxonomic revisions and checklists, namely: on *Ammobates* Latreille, 1809 (Warncke 1983), *Andrena* (Warncke 1967, 1976a; Dardón et al. 2010), Colletidae

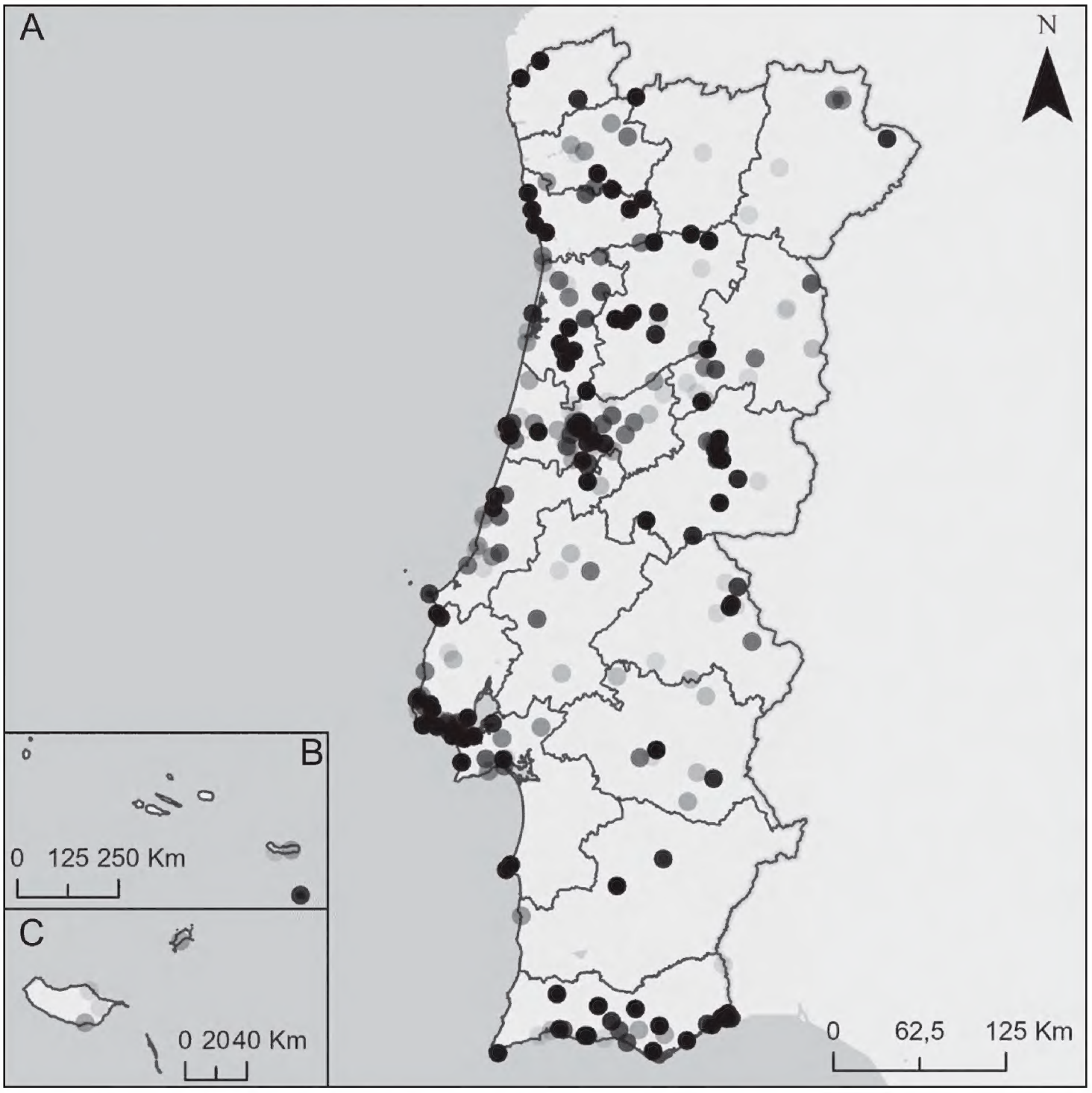

Figure 2. Distribution map of MCUC Bees of Portugal collection records (**A** continental territory **B** Archipelago of the Azores **C** Archipelago of Madeira). Paler dots have fewer records (minimum of 1 record), and darker dots have more records (up to 2170 records at a single site - Pinhal de Marrocos, Coimbra).

(Ornosa and Ortiz-Sánchez 2004), *Dufourea* Lepeletier, 1841 (Ebmer 1984), *Lasioglossum* (Ebmer 1979, 2000, 2003, 2014), Megachilidae (Diniz 1989), *Melecta* Latreille, 1802 (Lieftinck 1980), Melittidae (Ornosa and Ortiz-Sánchez 1998), *Nomiapis* Cockerell, 1919 (Warncke 1976b), Panurginae (Warncke 1972), *Thyreus* Panzer, 1806 (Lieftinck 1968), and other general publications (Dusmet 1932; Diniz 1959, 1960; Baldock et al. 2018).

New species to the fauna of Portugal

A total of 14 species are reported here as new to the Portuguese fauna. These include specimens that were already identified (but not published before) and specimens that

were not previously identified. The identifier is H. Gaspar unless stated otherwise. When the collector is not specified, it means that it is unknown. Unless stated otherwise, all the specimens belong to the MCUC Bees of Portugal collection.

ANDRENIDAE

Andrena (*Cryptandrena*) *rotundata* Pérez, 1895

New data. Portugal • Lisboa, Lourinhã, Praia da Areia Branca; 29.vi.1969; 1♂ (ZOO.0017521, Fig. 3A); det. T.J. Wood, leg. M.A. Diniz.

Remarks. The first record of the species in continental Europe [otherwise in Sardinia, Sicily (TJW, unpublished), and northern Africa]. This is a surprising discovery, considering the isolation of this locality in relation to the remaining distribution. Further study and examination of collections from southern Iberia is warranted.

Distribution. Coastal central region.

Andrena (*Hoplandrena*) *ferox* Smith, 1847

New data. Portugal • Aveiro, Mealhada, Buçaco; 1876–1910; 1♂ (ZOO.0032110) • Coimbra, Coimbra, Ponte da Portela; 22.iv.1968; 1♂ (ZOO.0027629, Fig. 3B); leg. M.A. Diniz • Guarda, Sabugal, Santo Estêvão; 25.iv.2023; 1♀ (C4705); leg. H. Gaspar, FLOW.

Remarks. Specially associated with *Quercus* L. forests, the new findings are from sites with relatively well-preserved forests of this type. *A. ferox* is found here and there in more temperate parts of northern Spain, but these records noticeably expand the Iberian range.

Distribution. Central region.

HALICTIDAE

Lasioglossum (*Sphecodogastra*) *intermedium* (Schenck, 1868)

New data. Portugal • Lisboa; 1876–1910; 1♀ (ZOO.0031986); det. S. Flaminio • Coimbra, Coimbra, Ponte da Portela; 09.iv.1968; 1♀ (ZOO.0028768, Fig. 3C); det. S. Flaminio, leg. M.A. Diniz • Coimbra, Coimbra, Pinhal de Marrocos; 10.iv.1968; 1♀ (ZOO.0028772); 07.v.1968; 1♀ (ZOO.0028802, UMONS); det. S. Flaminio, leg. M.A. Diniz • Porto, Amarante; 16.vii.1969; 1♀ (ZOO.0020259); det. S. Flaminio, leg. M.A. Diniz.

Remarks. Prior to the publication of these records here, this species had very scarce records in Iberia (Ortiz-Sánchez and Pauly 2017; Fidalgo et al. 2020). This finding expands considerably the distribution of this species westwards in the Iberian Peninsula.

Distribution. Central and northern regions.

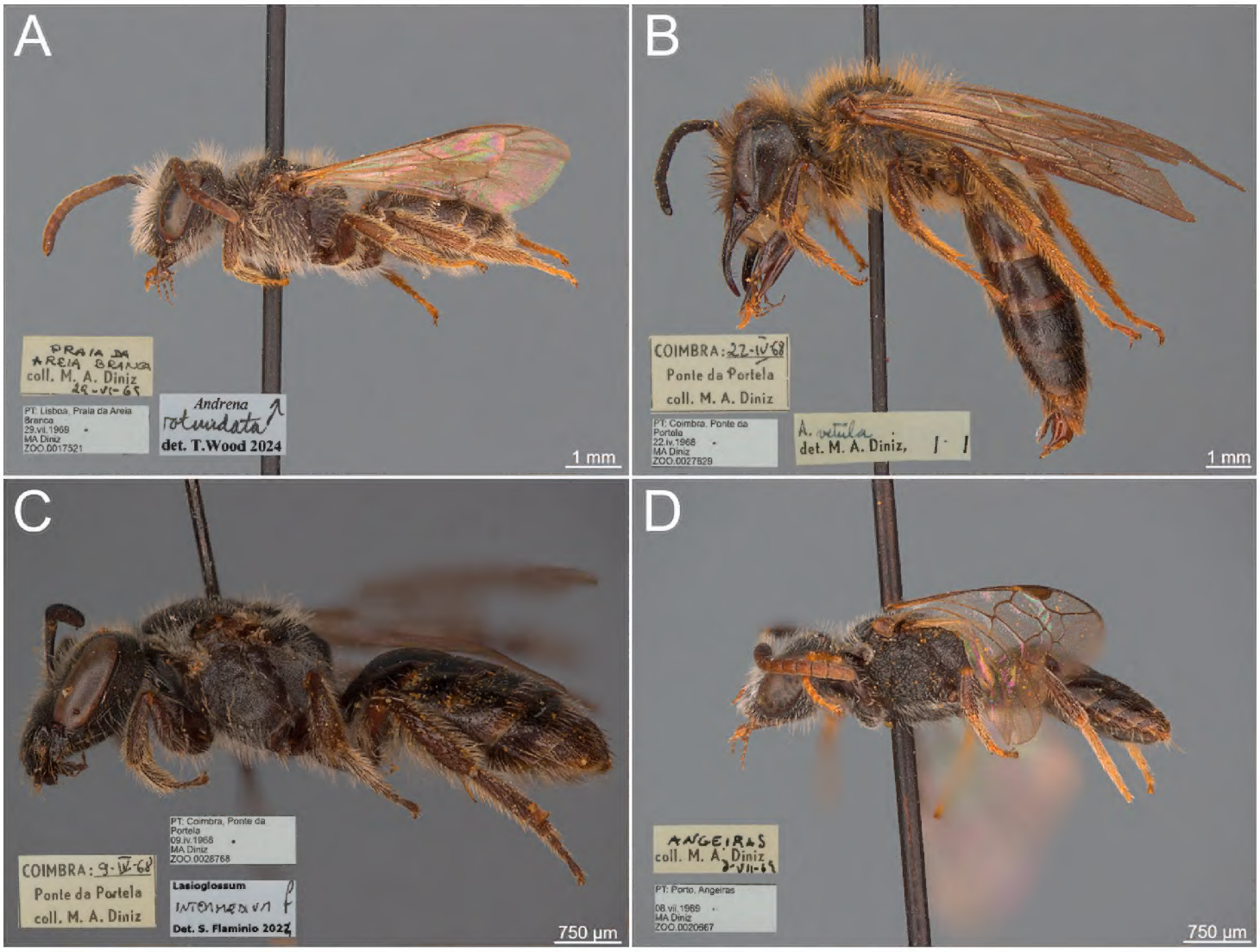

Figure 3. New additions to the Portuguese bee fauna **A** *Andrena* (*Cryptandrena*) *rotundata* Pérez, 1895, male profile (ZOO.0017521) **B** *Andrena* (*Hoplandrena*) *ferox* Smith, 1847, male profile (ZOO.0027629) **C** *Lasioglossum* (*Hemihalictus*) *intermedium* (Schenck, 1868), female profile (ZOO.0028768) **D** *Sphecodes pinguiculus* Pérez 1903, male profile (ZOO.0020667).

Sphecodes pinguiculus Pérez, 1903

New data. Portugal • Porto, Matosinhos, Angeiras; 08.vii.1969; 1♂ (ZOO.0020667, Fig. 3D); leg. M.A. Diniz.

Distribution. Northern region.

APIDAE

Amegilla (*Amegilla*) *ochroleuca* (Pérez, 1879)

New data. Portugal • Coimbra; July; 1♀ (ZOO.0024729) • Viseu, Oliveira de Frades; 1876–1910; 4♂ (ZOO.0024663, ZOO.0024664, ZOO.0024668, ZOO.0024671); det. M.A. Lieftinck 1962 & H. Gaspar • Viseu, Vouzela; 1876–1910; 2♀ (ZOO.0024728, ZOO.0029778); leg. unknown • Coimbra, Penela; 1876–1910; 4♀ (ZOO.0029779, ZOO.0029780, ZOO.0032214, ZOO.0032263) • Braga, Vizela; vii.1899; 2♀ (ZOO.0029869, ZOO.0029870) • Coimbra, Mi-

randa do Corvo, Rio de Vide; viii.1950; 1♀ (ZOO.0024744); leg. A.A. dos Santos • Coimbra, Penela; viii.1951; 1♀ (ZOO.0032183); leg. Crawford • Lisboa, Sintra; ix.1951; 1♀ (ZOO.0032184); leg. Crawford • Viseu, Resende; 13.vii.1953; 1♀ (RMNH.INS.1663113); det. M.A. Lieftinck, leg. N.F. d'Andrade; RMNH • Viseu, Resende; 15.vii.1953; 1♀ (ZOO.0024657, Fig. 4A); det. M.A. Lieftinck 1962 & H. Gaspar, leg. N.F. d'Andrade • Viseu, Resende; 16–19.vii.1957; 2♂ (RMNH.INS.1265330, RMNH.INS.1265331); det. T.J. Wood leg. P.M.F. Verhoeff; RMNH • Coimbra, Miranda do Corvo, Rio de Vide; viii.1957; 4♀, 1♂ (ZOO.0024658, ZOO.0024660, ZOO.0024661, ZOO.0024662, ZOO.0024669); det. M.A. Lieftinck 1962 & H. Gaspar, leg. M.A. Diniz • Coimbra, Coimbra, Cumeada; 09.v.1963; 1♂ (ZOO.0024677, Fig. 4B); leg. F.F. Almeida • Porto, Santo Tirso, Serra de São Miguel; 27.vii.1963; 2♂ (ZOO.0024675, ZOO.0024676); det. M.A. Lieftinck 1965 & H. Gaspar, leg. M.A. Diniz • Coimbra, Miranda do Corvo, Rio de Vide; 28.v.1964; 1♀ (ZOO.0024659); leg. A.A. dos Santos • Coimbra, Coimbra, Tovim; 20.vii.1966; 1♀, 1♂ (ZOO.0024666, ZOO.0024674); leg. F. França • Aveiro, Albergaria-a-Velha; 27.vii.1968; 1♀, 1♂ (ZOO.0024665, ZOO.0024673); leg. M.A. Diniz • Coimbra, Figueira da Foz; 09.viii.1968; 1♀ (ZOO.0024667); leg. M.A. Diniz.

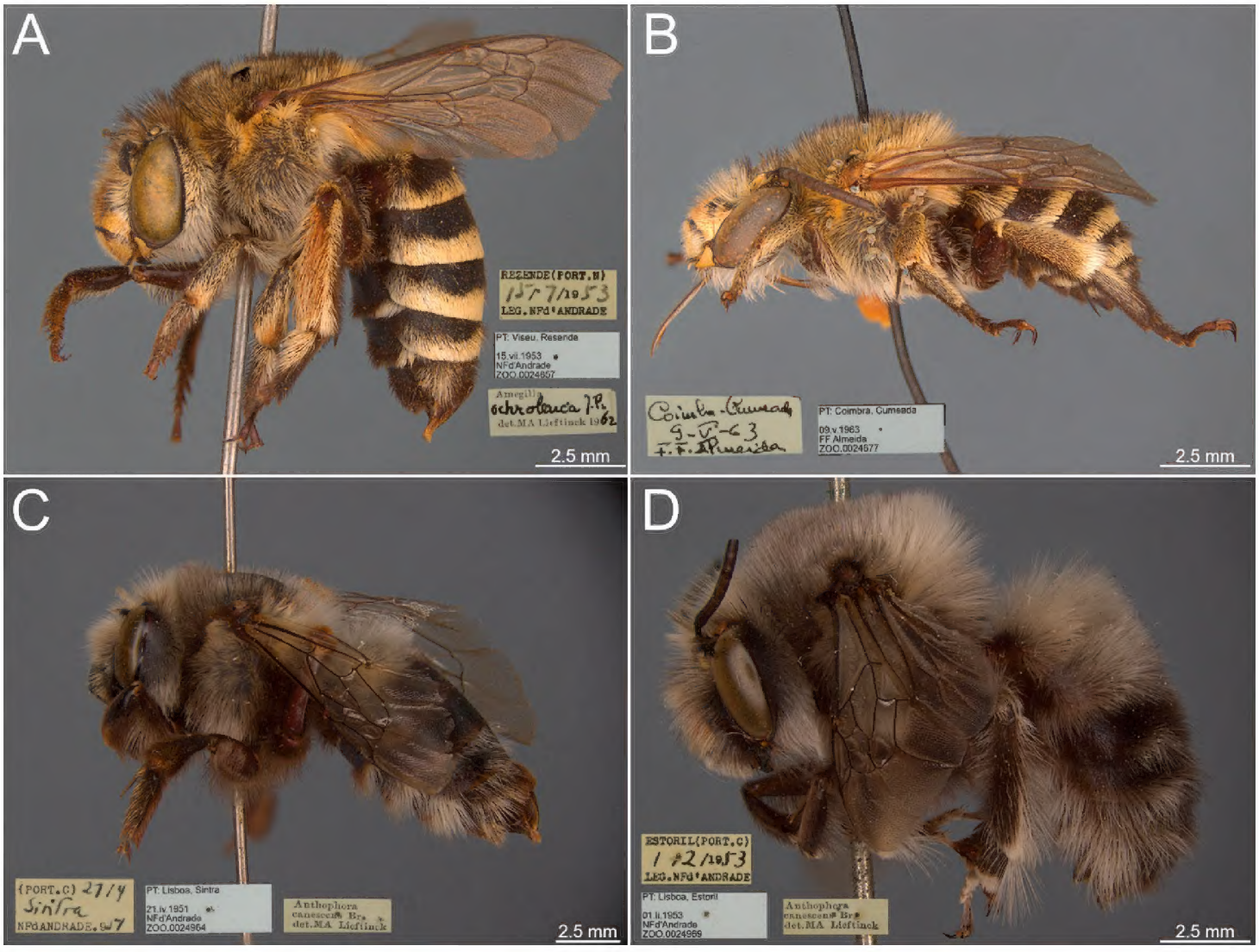

Figure 4. New additions to the Portuguese bee fauna. *Amegilla* (*Amegilla*) *ochroleuca* (Pérez, 1879) **A** female profile (ZOO.0024657) and **B** male profile (ZOO.0024677); *Anthophora* (*Anthophora*) *canescens* Brullé, 1832 **C** female profile (ZOO.0027629) and **D** male profile (ZOO.0024969).

Remarks. Although some of the material was already identified, these identifications were made after the broad bee faunistic publications of M.A. Diniz, and for that reason, remained unpublished and unknown.

Distribution. Northern and central regions.

Anthophora (*Anthophora*) *canescens* Brullé, 1832

New data. Portugal • Beja; 1876–1910; 4♀, 1♂ (ZOO.0024966*, ZOO.0025433, ZOO.0025434, ZOO.0026524, ZOO.0024972*); det. M.A. Lieftinck (marked with *) & H. Gaspar • Lisboa, Sintra; 21.iv.1951; 1♀ (ZOO.0024964, Fig. 4C); det. M.A. Lieftinck & H. Gaspar, leg. N.F. d'Andrade • Lisboa, Estoril; 01.ii.1953; 2♂ (ZOO.0024969*, Fig. 4D, ZOO.0024970); det. M.A. Lieftinck (marked with *) & H. Gaspar, leg. N.F. d'Andrade • Setúbal, Almada, Caparica; 08.iii.1953; 1♂ (ZOO.0024971); leg. N.F. d'Andrade • Lisboa; 03.iv.1955; 1♀ (ZOO.0024965); det. M.A. Lieftinck & H. Gaspar, leg. N.F. d'Andrade • Faro, Silves, Armação de Pera; 06.iv.1966; 2♀ (ZOO.0024967, ZOO.0024968); leg. M.A. Diniz.

Remarks. This is a similar example to the previous species, where some specimens were determined but records were never published.

Distribution. Central and southern regions.

Anthophora (*Anthophora*) *senescens* Lepeletier, 1841

New data. Portugal • Setúbal; 1876–1910; 1♀ (ZOO.0025425) • Santarém, Mação, Cardigos; 1876–1910; 1♀ (ZOO.0029774) • Setúbal, Almada, Caparica; 08.iii.1953; 1♂ (ZOO.0025220, Fig. 5B); det. M.A. Lieftinck & H. Gaspar, leg. N.F. d'Andrade • Setúbal, Almada, Trafaria; 08.iii.1953; 1♀ (ZOO.0025438, Fig. 5A); leg. N.F. d'Andrade • Setúbal, Seixal, Corroios; 02.iv.1953; 1♀ (ZOO.0025217); det. M.A. Lieftinck & H. Gaspar, leg. N.F. d'Andrade • Setúbal, Seixal; 17.iv.1954; 1♀ (ZOO.0025443); leg. N.F. d'Andrade • Faro, Monchique; 11.iv.1966; 1♂ (ZOO.0025223); leg. M.A. Diniz • Faro, Silves, Praia dos Beijinhos; 12.iv.1966; 2♂ (ZOO.0025221, ZOO.0025222); leg. M.A. Diniz.

Remarks. This is a similar example to the previous two species.

Distribution. Central and southern regions.

Anthophora (*Caranthophora*) *pubescens* (Fabricius, 1781)

New data. Portugal • Bragança, Bragança, Gondesende; 08.vii.2022; 1♀, 1♂ (API 6069, Fig. 5C, API 6071, Fig. 5D); det. & leg. A. Soares, MUHNAC.

Remarks. This species is probably distributed in a larger area in the northern parts of the country.

Distribution. Northern region.

Figure 5. New additions to the Portuguese bee fauna. *Anthophora* (*Anthophora*) *senescens* Lepeletier, 1841 **A** female profile (ZOO.0025438) and **B** male profile (ZOO.0025220); *Anthophora* (*Caranthophora*) *pubescens* (Fabricius, 1781) **C** female profile (API 6069) and **D** male profile (API 6071).

Bombus (*Thoracobombus*) *ruderarius* (Müller, 1776)

New data. Portugal • Coimbra, Figueira da Foz; 20.viii.1978; 1♀, 1♂ (ZOO.0026789, Fig. 6A, ZOO.0026788, Fig. 6B); leg. M.A. Diniz.

Distribution. Central region.

Nomada (*Holonomada*) *flavopicta* (Kirby, 1802)

New data. Portugal • Aveiro, Águeda, Pateira de Fermentelos; 17.v.1967; 1♀ (ZOO.0023664, Fig. 6C); leg. J. Batista.

Remarks. *N. flavopicta* is a brood parasite of summer-flying *Melitta* species (Smit 2018), which in Portugal are largely restricted to the central-northern part of the country (Baldock et al. 2018).

Distribution. Central region.

Figure 6. New additions to the Portuguese bee fauna. *Bombus* (*Thoracobombus*) *ruderarius* Müller, 1776 **A** female profile (ZOO.0026789) and **B** male profile (ZOO.0026788); *Nomada* (*Holonomada*) *flavopicta* (Kirby, 1802) **C** female profile (ZOO.0023664); *Nomada* (*Mininomada*) *connectens* Pérez, 1884 **D** male profile (ZOO.0023647).

Nomada (*Holonomada*) *pectoralis* Morawitz, 1877

New data. Portugal • Leiria, Caldas da Rainha, Salir do Porto; 11.vii.2019; 1♀; leg. A. Livory & R. Coulomb, A. Livory Colln., France.

Remarks. The host is unknown (Smit 2018), but the late flight period, large body size, and phylogenetic position (Straka et al. 2024) suggests use of *Tetralonia* species as hosts.

Distribution. Central region.

Nomada (*Mininomada*) *connectens* Pérez, 1884

New data. Portugal • Castelo Branco; 1876–1910; 1♂ (ZOO.0023646); det. M. Schwarz 1965 & H. Gaspar • Faro, Vila Real de Santo António, Monte Gordo; 24.vii.1967; 1♂ (ZOO.0023647, Fig. 6D); leg. M.A. Diniz.

Distribution. Central and southern regions.

Figure 7. New additions to the Portuguese bee fauna. *Nomada* (*Nomada*) *flavilabris* Morawitz, 1875, female profile (ZOO.0023713).

Nomada (*Nomada*) *flavilabris* Morawitz, 1875

New data. Portugal • Coimbra, Coimbra, Ponte da Portela; 10.iii.1968; 1♀ (ZOO.0023713, Fig. 7); leg. M.A. Diniz.

Distribution. Central and southern regions.

Thyreus picaron Lieftinck, 1968

New data. Portugal • Viana do Castelo, Ponte da Barca, Entre Ambos-os-Rios; 11.vii.2020; 1♂; leg. K. Janssen, K. Janssen Colln., Belgium.

Remarks. The host of *T. picaron* is unknown, but it is likely to be either *Amegilla ochroleuca* (Pérez, 1879) or *A. garrula* Rossi, 1790 (the latter is not reported from Portugal), or possibly both.

Distribution. Northern region.

Species removed

A list of 19 species previously mentioned for Portugal by various sources that are considered not to be part of the fauna is presented here. We consider these species absent from the Portuguese fauna based on the reasons stated below.

APIDAE

Eucera (*Hetereucera*) *punctatissima* Pérez, 1895

Reported by Reverté et al. 2023. *Eucera decolorata* Gribodo, 1924 was considered part of the Portuguese fauna by Baldock et al. 2018. Dorchin, 2023 concluded, based on type study, that *E. decolorata* was a junior synonym of *E. confinis* Pérez, 1895, and that *E. decolorata* in Portugal was represented by a second species, *E. punctatissima*. This was the situation reported by Reverté et al. 2023. Further examination of specimens (A. Dorchin, pers. comm.) has led to the conclusion that *E. punctatissima* is present only in North Africa, and the correct name for *E. decolorata sensu* Baldock et al. 2018 is *E. confinis*.

Thyreus scutellaris (Fabricius, 1781)

Reported by Reverté et al. 2023. Old records of this species exist because *T. orbatus* (Lepeletier, 1841) was incorrectly treated as *T. scutellaris* (Fabricius, 1781) auctorum. This was the typical state across Europe until the work of Beaumont, 1939, who recognized that researchers were misapplying the name *T. scutellaris* that was originally described from Siberia. Wood et al. 2020 concluded that the reports of *T. scutellaris* from Portugal by Dusmet 1931 and Diniz 1959 were misidentifications and excluded the species from the Portuguese list. Reverté et al. 2023 reported *T. scutellaris* from Portugal, but we believe this is a repetition of the *T. scutellaris* auctorum concept from earlier literature. We therefore continue to exclude *T. scutellaris* from the Portuguese fauna.

COLLETIDAE

Hylaeus (*Prosopis*) *purpurissatus* (Vachal, 1895)

Reported by Reverté et al. 2023. The taxonomic work around this species is still needed; these records are most likely *H. incongruus* Förster, 1871 in a broad sense (see discussion in Ghisbain et al. 2023), but taxonomic work is ongoing in this group and the situation remains fluid. For this reason, we treat only *H. incongruus* in Portugal, pending further clarifications.

HALICTIDAE

Halictus (*Monilapis*) *consobrinus* Pérez, 1895

This species has been greatly confused. Reported from Portugal in Baldock et al. 2018 based on two females identified by Ebmer (Kuhlmann 1996), as well as unpublished specimens. As part of the subgenus *Monilapis* Cockerell, 1931, females are essentially unidentifiable. Following the exclusion of this species from the Iberian Peninsula in Ortiz-Sánchez and Pauly 2017, we also remove this species, which is most likely to exclusively occur in North Africa (Ghisbain et al. in prep.).

Halictus (*Acalcaripes*) *patellatus* Morawitz, 1873

Reported by Ortiz-Sánchez and Pauly 2017 and Reverté et al. 2023. The confident identification of this species can only be done with males, and only females have been reported from Portugal to date. Baldock et al. 2018 considered the species unproven in Portugal for this reason. We will maintain this position until males can be found in Portugal.

Sphecodes algeriensis Alfken, 1914

Reported by Reverté et al. 2023. This is currently a junior synonym of *S. alternatus algeriensis* Alfken, 1914 (Ghisbain et al. 2023), although it likely deserves species status (Wood et al. 2024). At present, we do not accept it at a specific level until revisionary work is done on a larger scale.

MEGACHILIDAE

Megachile (*Chalicodoma*) *parietina* (Geoffroy, 1785)

According to Ghisbain et al. 2023, *M. parietina* and *M. baetica* (Gerstäcker, 1869) are two valid species at present. Since only one of the two species/subspecies is present in Portugal, we replaced *M. parietina* on the Portuguese list with *M. baetica*.

Osmia (*Pyrosmia*) *cyanoxantha* Pérez, 1879

Reported by Reverté et al. 2023. The situation with the subgenus *Pyrosmia* Tkalců, 1975 is currently complex, and requires revision. Müller in Ghisbain et al. 2023 returned *O. leucopyga* Ducke, 1899 to species status, revoking the synonymy with *O. lobata* Friese, 1899 made by Warncke 1992. As well as replacing *O. lobata* on the Portuguese list, *O. leucopyga* also replaces *O. cyanoxantha* Pérez, 1879 *sensu auctorum* in Iberia, or at least in southern Iberia (A. Müller, pers. comm.). Consequently, both *O. cyanoxantha* and *O. lobata* are replaced on the Portuguese list by a single species, *O. leucopyga*.

Other species removed, previously included for unclear reasons

The following species are mentioned as present in mainland Portugal by Reverté et al. 2023 for unclear reasons and thus are not included in this update:

APIDAE

Anthophora (*Anthophora*) *punctilabris* Pérez, 1879

There is no published evidence for this species in Portugal.

***Eucera* (*Hetereucera*) *oraniensis* Lepeletier, 1841**

There is no published evidence for this species in Portugal.

***Nomada* (*Collicula*) *halophila* Wood, 2022**

There is no published evidence for the presence of *N. halophila* in Portugal. The species is currently known only from the province of Málaga in southern Spain (Wood 2022). The host *Andrena* (*Notandrena*) *juliana* Wood, 2021 is present in Portugal, and so *N. halophila* may eventually be found here, but this requires demonstration with collected specimens.

COLLETIDAE

***Hylaeus* (*Hylaeus*) *gracilicornis* (Morawitz, 1867)**

There is no published evidence for this species in Portugal.

HALICTIDAE

***Halictus* (*Monilapis*) *tetrazonius* (Klug, 1817)**

This species is eastern, with a western limit in the Balkans and Central Europe. It was excluded from the Portuguese fauna by Wood et al. 2020.

***Lasioglossum* (*Lasioglossum*) *laterale* (Brullé, 1832)**

There is no published evidence for this species in Portugal.

***Nomiapis* (*Nomiapis*) *monstrosa* (Costa, 1861)**

This is the result of long-running confusion within the genus *Nomiapis* (Baldock et al. 2018; Wood et al. 2020; Wood and Le Divelec 2022); *N. monstrosa* is absent from Iberia.

***Sphecodes intermedius* Blüthgen, 1923**

There is no published evidence for this species in Portugal.

***Sphecodes majalis* Pérez, 1903**

There is no published evidence for this species in Portugal.

Sphecodes pseudocrassus Blüthgen, 1924

There is no published evidence for this species in Portugal.

MEGACHILIDAE

Stelis (*Stelis*) *ornatula* Klug, 1807

This species is known only in Portugal from Madeira (Kasparek 2015).

Continental Portugal updated checklist

Considering the 14 new species and the 19 removed or excluded species, the total species richness of the continental Portugal bee fauna stands at 736, which along with other works published since 2020 represents a meaningful increase from the last total of 712 (Wood et al. 2020). The complete list, with reference to the first report of each species, is provided in Suppl. material 1: table S2.

Type material from MCUC

A total of six type specimens were found in MCUC Bees of Portugal collection and three specimens in other international material on the MCUC collection, altogether covering six species. When not specified, the collector is unknown.

COLLETIDAE

Colletes (*Colletes*) *dinizi* Kuhlmann, Ortiz & Ornosa, 2001

Holotype. Portugal • Setúbal, Sines; 26.vii.1969; 1♂ (ZOO.0016292, Fig. 8B); det. M. Kuhlmann 2001, leg. M.A. Diniz.

Paratype. Portugal • Setúbal, Sines; 25.vii.1969; 1♀ (ZOO.0016293, Fig. 8A); det. M. Kuhlmann 2001, leg. M.A. Diniz.

HALICTIDAE

Lasioglossum (*Sphecodogastra*) *dusmeti* (Blüthgen, 1924)

Of no type value (labelled as cotype by Blüthgen). Spain • Castilla-La Mancha, Ciudad Real, Pozuelo de Calatrava; undated; 1♀ (ZOO.0018835, Fig. 8C); det. P. Blüthgen, leg. La Fuente.

Syntype (labelled as cotype by Blüthgen). Spain • Comunidad de Madrid, Madrid, Sierra de Guadarrama; 23.viii.1915; 1♂ (ZOO.0018841, Fig. 8D); det. P. Blüthgen, leg. J.M. Dusmet Alonso.

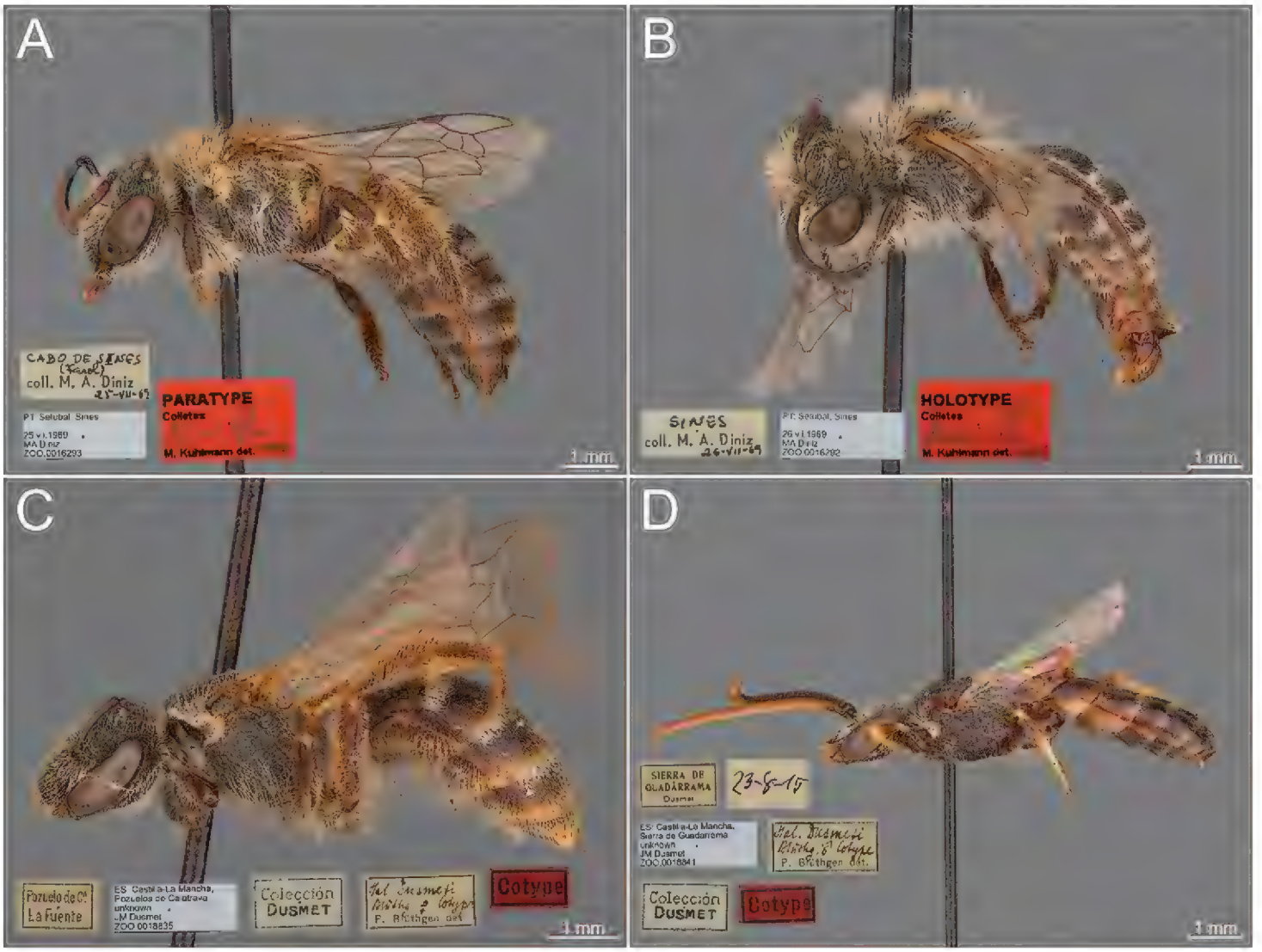

Figure 8. Type material. *Colletes* (*Colletes*) *dinizi* Kuhlmann, Ortiz & Ornosa, 2001 **A** female paratype profile (ZOO.0016293) and **B** male holotype profile (ZOO.0016292); *Lasioglossum* (*Sphecodogastra*) *dusmeti* (Blüthgen, 1924) **C** female of no type value profile (ZOO.0018835) and **D** male syntype profile (ZOO.0018841).

Remarks. The specimen from Pozuelo de Calatrava (ZOO.0018835) was labelled as a co-type by Blüthgen, and he may indeed have used it to help define the species whilst writing the description, but as he did not explicitly mention this specimen in his publication, it is of no type value. Ebmer (1995) in examining type material in the Madrid museum did not think it necessary to designate a lectotype from specimens there, as he argued that Blüthgen adequately described the species and that its recognition was clear. We therefore treat only the male from the Sierra de Guadarrama as syntypic.

APIDAE

Anthophora (*Pyganthophora*) *romandii* Dours, 1869

Possible syntype (labelled as paratype by Lieftinck). Algeria • text not decoded; 15.i.1842; 1♂ (ZOO.0024955, Fig. 9A); det. M.A. Lieftinck 1962.

Remarks. The collection of Dours was lost, as it was destroyed in a fire (Wood 2023). As such, the location of Dours' types is usually simple; they are lost. However, *A. romandii* was described from females from the collection of Lepeletier, and males from Algeria and

Figure 9. Type material **A** *Anthophora* (*Pyganthophora*) *romandii* Dours, 1869, male possible syntype profile (ZOO.0024955) **B** *Nomada* (*Collicula*) *beaumonti* Schwarz, 1967, male paratype profile (ZOO.0023634) **C** *Nomada* (*Gestamen*) *linsenmaieri* Schwarz, 1974, male paratype profile (ZOO.0023720) and **D** *Nomada* (*Gestamen*) *rubricoxa* Schwarz, 1977, female paratype profile (ZOO.0023788).

central France from the collections of Dours and Sichel (Dours 1869). It is almost impossible to know the origin of this male specimen from Algeria that was collected in 1842, but it is old enough to potentially be a syntype of *A. romandii*. If it was traded from the Paris collection by M.A. Diniz, it could potentially be from the Sichel collection, but at present, this has not been proven. Further study is required before solid conclusions can be drawn.

Nomada (*Collicula*) *beaumonti* Schwarz, 1967

Paratype. Portugal • Coimbra, Figueira da Foz, Serra da Boa Viagem; 30.iv.1963; 1♂ (ZOO.0023634, Fig. 9B); det. M. Schwarz 1965, leg. M.A. Diniz.

Nomada (*Gestamen*) *linsenmaieri* Schwarz, 1974

Paratype. Portugal • Castelo Branco; 1876–1910; 1♂ (ZOO.0023720, Fig. 9C); det. M. Schwarz 1965.

Figure 10. Type material. *Nomada* (*Gestamen*) *rubricoxa* Schwarz, 1977 **A** female paratype profile (ZOO.0023789) and **B** male paratype profile (ZOO.0023802).

Nomada (*Gestamen*) *rubricoxa* Schwarz, 1977

Paratypes. Portugal • Castelo Branco, Lousa; 1876–1910; 1♀ (ZOO.0023788, Fig. 9D); det. M. Schwarz 1965 • Castelo Branco, Colégio de São Fiel; 1876–1910; 1♀ (ZOO.0023789, Fig. 10A); det. M. Schwarz 1965 • Guarda, Serra da Estrela; 1876–1910; 1♂ (ZOO.0023802, Fig. 10B); det. M. Schwarz 1965.

Discussion

The MCUC Bees of Portugal collection is now confirmed as one of the most relevant national historical collections still existing in Portugal, comprising the most extensive recorded collection in number of species and specimens of bees for Portugal from the late 19th century and mid-20th century.

The known Portuguese bee fauna is once again increasing in the number of species, following the trend since the publication of the first comprehensive checklist of Baldock et al. 2018 (which reported 355 new species out of 680 species) and of subsequent publications which increased the diversity of bee fauna or made nomenclatural changes (Wood et al. 2020, 2021; Litman et al. 2021; Gaspar et al. 2022, 2023; Praz et al. 2022; Soares et al. 2022; Wood and Le Divelec 2022; Wood and Ortiz-Sánchez 2022; Bogusch 2023; Cross 2023; Reverté et al. 2023; Wood 2023). Most of the newly reported species here come from the MCUC collection, setting another example of the importance and contribution of historical collections to national checklists (i.e., Herrera Mesías and Weigand 2021). The current number of continental species is set at 736, and it is likely to continue growing due to future revisions to national collections, extensive sampling and monitoring efforts. A further 10 species not present on the mainland are found on the Portuguese islands (Wood et al. 2020).

This study also reveals that the presence of type material of bees in Portugal, particularly in the MCUC, is relatively limited, as most material is stored in centralized

European institutions with easier access for further studies, and which had well-developed taxonomic infrastructure historically, most clearly seen in France. While most of the type materials currently held at the MCUC are associated with taxonomic work done on the collection, some also originated from material exchanges. The MCUC collection includes material of one of the two bee species currently endemic to continental Portugal - *Colletes* (*Colletes*) *dinizi* Kuhlmann, Ortiz & Ornosa, 2001 (the other being *Protosmia* (*Protosmia*) *lusitanica* Le Goff & Gonçalves, 2018) (Reverté et al. 2023). The most remarkable potential type material is that of *Anthophora* (*Pyganthophora*) *romandii*, collected in 1842, the oldest confirmed record in the MCUC collection, that may have been acquired through an unknown exchange of material.

Species representation

Although the level of species representation of the MCUC Bees of Portugal collection is satisfactory and enables the development of taxonomic capacity in this group, it still needs improvement. Underrepresented genera are predominantly those that are very rare, being in several cases absent from the collection. These include genera with specific habitat specialisations (such as *Halopanurgus*) and parasitic rarities (such as *Ammobatoides*, *Biastes*, *Ensliniana*, and *Pasites*). Additionally, some bee genera had reduced species representation due to incorrect collection handling that led to the loss of specimen labels and admixture with material from outside Portugal, thus preventing their use in checklists. This was observed in the genera *Colletes* Latreille, 1802, *Hylaeus*, *Sphecodes* Latreille, 1804, *Osmia* Panzer, 1806, *Hoplitis*, *Megachile* Latreille, 1802, and some of the rarer genera such as *Lithurgus* and *Melitta*. Yet, although not contributing for the checklist, these unlabelled specimens and other international material can be used as reference material.

The species representation in significant Portuguese bee collections is currently being improved within the scope of the ARCADE project (2024–25), and the MCUC collection stands as a vital asset.

Geographic representation

This review highlights a string of geographical gaps in the representation of the MCUC Bees of Portugal collection. There is a denser distribution of records around specific collector-dependent localities, particularly around each collector's home, leisure, or vacation areas (and travel paths between these, often through train stations). A striking example are the records from M.A. Diniz, which are well documented.

The gaps in geographic representation have already been pointed out by Baldock et al. 2018 and Wood et al. 2020, with most inland regions of Portugal being highly underrepresented (with few exceptions like Serra da Estrela or near Bragança, where higher sampling efforts were made). This reflects private collectors' lack of visits to these regions, as they often chose holiday destinations in the southern region, such as the Algarve. Later works, especially Gaspar et al. 2022, 2023, have largely contributed to Castelo Branco district and, in part, Guarda. In the present work, beyond these ar-

eas, there is a significant contribution to Coimbra, Viseu, Porto and Aveiro. Nevertheless, there are still very considerable geographic gaps, especially in all the inland regions, especially Beja, Évora, Portalegre, Santarém, Guarda, Bragança, Vila Real and Viana do Castelo. Increasing sampling efforts in these unexplored regions have excellent potential for discoveries (i.e., Cornalba et al. 2024) and should be exploited in the future.

Finally, the fauna of the insular territories, Açores and Madeira, is very species-poor. Although it is less represented here regarding the number of specimens, it is believed to be well documented (Weissmann et al. 2017; Kratochwil et al. 2022).

Phenological representation

The MCUC Bees of Portugal collection significantly contributes to phenological representation, as the most prolific collectors (namely M.A. Diniz and N.F. d'Andrade) collected intensely year-round. This is a big difference from most published data for Portugal, which is associated with short visits of non-resident collectors. Even when intense field collections occur, they are still restricted in time since many visits were made during holidays (Baldock et al. 2018). Therefore, the MCUC collection contributes to overcoming previous phenological bias, as some species were likely underrepresented in previous assessments due to their active period being outside the peaks in spring and summer periods, where collectors often concentrate their efforts.

Historic representation

The oldest records reported here are in line with those previously reported for Portugal (Baldock et al. 2018). Nevertheless, there is a clear positive contribution to several periods, most noticeably to 1876–1910 and the decades of the 1950s and 1960s. Before the publication of this dataset, there were around 3,000 published records from 1876–1990 (Baldock et al. 2018), with the majority of records reported by Baldock et al. (2018) coming from the contemporary period. Examination of the MCUC collection has contributed an additional 11,000 specimens (taking into account the removal of linked literature and hence duplication), resulting in almost five times the previously known number of records from this period.

This represents a giant leap in the available material for historical comparisons, especially for distributional and phenological changes. Unfortunately, even with precise georeferenced data, the lack of standardized sampling compromises the use of this data for population trends (especially the lack of abundance data), which is only now being tested and implemented in European Member states (Potts et al. 2024).

The detailed comparison to all the existing published records is quite demanding and goes beyond the scope of this work. Nevertheless, the knowledge of the Portuguese fauna still needs a significant effort towards collection expansion to represent the species (with both sexes) and its geographical, phenological and historical components, with supporting information on vital ecological knowledge such as habitat, visited flowers and pollen loads.

Previous taxonomic works and published records

The scarce documentation associated with the MCUC collection creates a major limitation to a clear insight into previous taxonomic work done on the collection. Aside from the information in the specimen labels, box disposition, and published literature, the donation and visitation activity were unavailable. Although we made an extensive search for documentation, it is likely that unlocated documentation still exists and could bring additional information to the collection. A relevant gap observed in our data is the absence of most records associated with the publications of Diniz 1959, 1960. This is odd as M.A. Diniz only studied the MCUC collection, and the localities referred to in these papers are not even referenced throughout the existing labels. This material remains unlocated, has probably been moved to another institution, destroyed, or has an unknown location within the MCUC collection.

Nevertheless, linking many records to their original published literature was possible. It is clear that this collection is of national importance and has contributed significantly to the knowledge of Portuguese fauna since its establishment.

The limited work done in the last two decades is thought to be associated with the lack of cataloguing and initial taxonomic revision, which is now significantly improved. We believe that the current dataset availability, collection centralization, and upgraded physical conditions (new cabinets, drawers, and trays) will promote the study of the collection and all its potential in national and international scientific work.

Conclusion

The MCUC Bees of Portugal collection provides a unique data source, largely contributing to filling some gaps in the representation of species, geographic scope, phenology and historical periods. The collection provided new additions to the bee fauna and holds some of the type materials existing in Portugal. It is a vital reference collection for developing bee taxonomy and reinforces the need to preserve, value and expand historical collections.

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Supplementary material 1

Supplementary information

Authors: Hugo Gaspar, Simone Flaminio, Albano Soares, Cristina Rufino, João Loureiro, Sílvia Castro, Thomas J. Wood

Data type: docx

Explanation note: **table S1.** On the details of MCUC number of specimens and species by genus. **table S2.** Providing an updated bee checklist for continental Portugal.

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